Site Surveys of the Mine Burial/Coastal Processes Experiment Site at the WHOI Coastal Observatory, Martha's Vineyard

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LONG-TERM GOALS

The long-term goal of the Mine Burial Program is to develop a better understanding of the coastal processes driving mine burial in shallow water coastal environments.

OBJECTIVES

The scientific objectives of the Mine Burial Program are to develop specific models for mine burial driven by coastal processes, to carry out both laboratory and field programs designed to test these models, and to develop probability statements with respect to the likelihood of mine burial. Two field areas have been identified for this project, one off St. Petersburg, Florida and the second off Martha's Vineyard, Mass. The University of New Hampshire is providing support for these objectives through two separate efforts: 1- the development of a web-based database for the Mine Burial Program and; 2- the collection, processing and analysis of high-resolution multibeam sonar data at the Martha's Vineyard field area. In conjunction with investigators from the University of Texas (John Goff), the University of Hawaii (Roy Wilkins), the Naval Research Lab (Mike Richardson), the USGS (Bill Schwab), and Woods Hole Oceanographic Institution (Peter Traykovski), we will use both the sonar data and the database to investigate the statistical properties of sedimentological and morphological variability, as well as track changes in bedform morphology and other time dependent seabed processes.

APPROACH

Detailed seafloor mapping and characterization will be critical to the success of both the experimental and theoretical components of the mine burial program. While the sedimentary properties of any survey area must be described before we can understand mine burial processes, we must also understand the variability and areal distribution of sediments in the target location – necessary to understand the natural variability of the burial process. We cannot rely on a few samples in the target area, but rather we need to map and characterize the area as completely, and with as much detail, as possible. Furthermore, we also cannot rely on a single map. We expect the seafloor to change over time – from season to season, and as bedforms migrate along the seafloor (one of the important burial mechanisms). We need the capability to map both the morphology and sedimentary properties of the target area as frequently and inexpensively as possible.

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Our approach is to use multibeam sonar mapping to monitor the seafloor and its changes. Multibeam mapping is quick, relatively inexpensive, and maps can be generated in near real time. The detailed bathymetry provided by the latest technology is unparalleled and in addition, many the systems can produce georeferenced backscatter maps that may provide critical insight into the distribution of seafloor properties.

Another component of our effort is the "ground-truthing" of sidescan and multibeam backscatter data against the measured sedimentological and geotechnical properties of the seafloor. Other investigators are collecting sediment samples for physical and geotechnical properties (Goff), subbottom profiles (Wilkens and Schock) and super-high resolution pole mounted sector scanning sonar records (Traykovski and Richardson). In support of these efforts, we have deployed our *in-situ* sound speed and attenuation probe (ISSAP – see GEOCLUTTER report) to make *in-situ* measurements of the near-surface sediment properties.

To conduct the detailed high-resolution multibeam surveys we have chosen a Reson 8125 multibeam sonar. With its dynamic focusing and 0.5 degree beamwidths, the 8125 has demonstrated the ability to achieve higher resolution and faster ping rates than any other multibeam sonar presently available. Very precise positioning is also critical to achieve the highest resolution possible and to enable meaningful repeat surveys. Thus we have also established an array of kinematic DGPS positioning receivers on Martha's Vineyard and have had diver-deployed sonar reflectors emplaced in the survey are to act as fiducials for repeat surveys. Finally we have established and are maintaining the Mine Burial Web Site to act as a central repository for Mine Burial experiment data as well as a focal point for information exchange and analysis.

WORK COMPLETED

The Woods Hole mine burial field area covers water depths from 8-18 m, within a relatively confined area focused around an existing coastal observatory node – the Martha's Vineyard Coastal Observatory (MVCO). The MVCO is located in 12 m of water and provides both power and hard-wired data telemetry back to shore.

In February 2001, the USGS, in conjunction with Peter Traykovski, collected DF1000 sidescan sonar and boomer data in a small (2 x 3.5 km) area centered around the MVCO site. Seven months later, the USGS conducted a regional bathymetric and sidescan sonar survey using a 134 kHz Submetrix interferometric sonar. These surveys provided a baseline within which to plan our detailed multibeam sonar survey. They also provide a baseline from which to understand regional sediment movements.

In July 2002 , we conducted the initial (baseline) Reson 8125 multibeam survey aboard the SAIC vessel *Ocean Explorer*. The survey consisted of a super high-resolution (4 m overlap) survey in a small area surrounding the MVCO node and mine burial sites, a slightly lower resolution survey (12 – 25 m overlap) in a box approximately 1 x 1 km surrounding the "target box" and a lower resolution survey (25 – 40 m line overlap) in a 3 x 5 km region surrounding the 1 x 1 km box. The vessel, the operators, and the Reson 8125 performed flawlessly through a range of sea states. We completed all of the work scheduled at precisely the coverage levels planned.

Between 4 and 6 August, 2002, the UNH team also participated in a cruise aboard the *R/V Cape Henlopen*. This cruise was designed to collect core samples and *in-situ* measurements that will help us better understand the nature of the seafloor geology as well as better interpret the sidescan sonar and backscatter data already collected. On this cruise the UNH team deployed the *I*n situ *S*ound *S*peed and

*A*ttenuation *P*robe (ISSAP – see GEOCLUTTER 2003 annual report for a description) making numerous measurements of *in situ* sound speed and attenuation in the mine burial area. In addition newly constructed resistivity probes were deployed on ISSAP adding *in situ* determinations of porosity to the suite of measurements made.

The first full suite of instrumented mines and mine-like objects were deployed at the MVCO site during the first week in October 2003. Three more high-resolution Reson 8125 multibeam surveys (these aboard a 30 foot RHIB – the *Loughrea Scanner)* were conducted of the 1 x 1 km box around the mine burial "target area." The first was immediately after deployment of the mines in October 2003 (to capture the state of the seafloor and the mines at the time of initial deployment), the next was in December of 2003 and the final survey in April of 2004 immediately before retrieval of the mines.

In order to facilitate the analysis of the multiple and disparate data sets collected at the Martha's Vineyard experimental site, we have compiled all available data sets (multibeam, sidescan, seismic, core, etc.) into both a standard GIS (ArcView) and into an interactive georeferenced 3-D environment (Figure 1). These compiled data sets are also available on the mine-burial website.

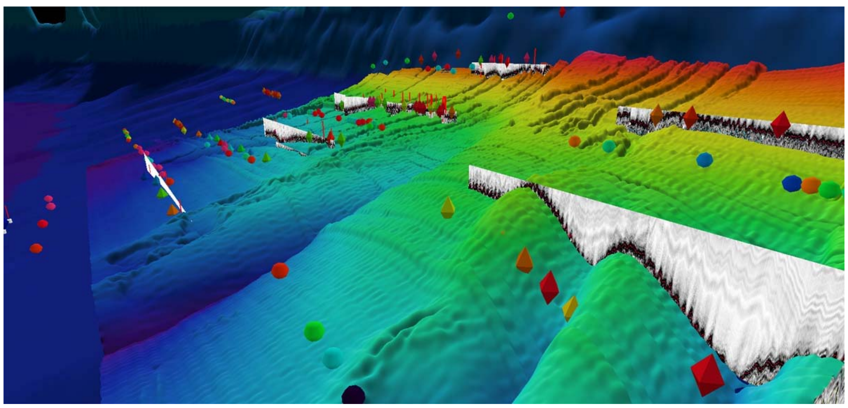

Figure 1. Scene from interactive 3-D view of MVCO database compilation. Plotted on bathymetry are core stations (red bars), velocity measurement sites (triangular polygons), grab samples (spheres) and seismic lines

RESULTS

The Reson 8125 continues to amaze us in its ability to resolve fine scale targets as well as produce large volumes of data; the total data volume for the four surveys exceeds 120 Gigabytes. Gridded data sets at various levels of resolution (from cm's to meters) have been generated and made available to other ONR researchers directly, and through the mine burial web site (see below). The node site and all diver-emplaced reflectors were clearly identified and most amazingly, we are able to resolve fields of individual ripples that are on the order of 2-5 cm in height (Figure 2, left). Of particular relevance to the mine burial program was our ability to resolve each of the mines as well as discriminate the type of mine (Fig. 2).

The detailed survey results present a clear picture of the dynamics of the environment and the nature of sediment movement in the region. Comparison of the surveys from July to April shows a clear change in the nature and boundaries of the "ripple-scoured depressions" (local topographic lows that are have

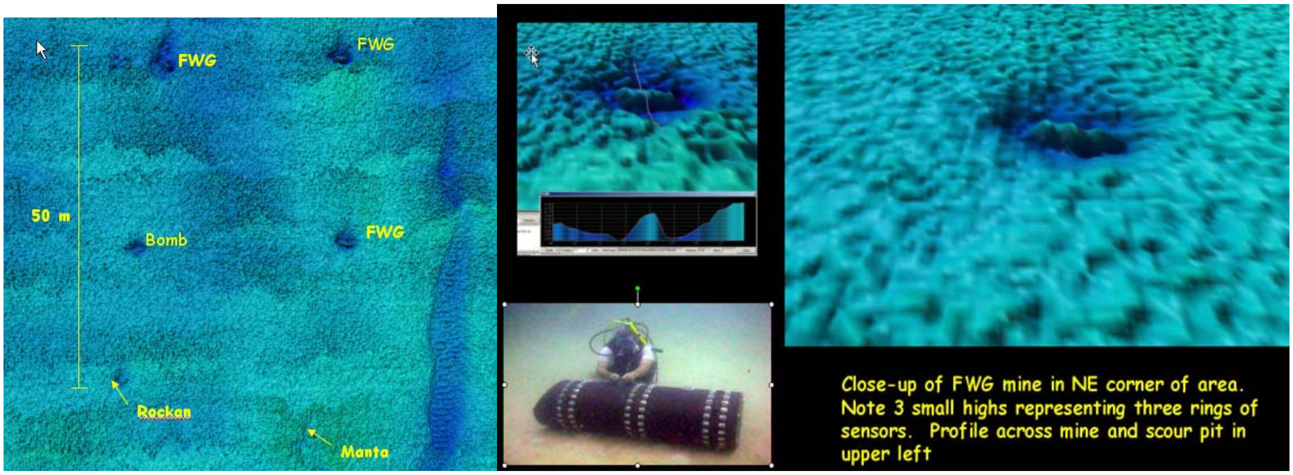

Figure 2 (left). Reson 8125 data showing 6 mines after deployment in October 2003. Each of the mine types can easily be recognized by its shape. Also note the eroded patches filled with ripples to the east (right) of the mines. These were not visible in earlier surveys and were subsequently covered in later surveys. (Right) - Close-up of NRL/FWG instrumented mine. Note three rings of sensors and sloped side that are clearly visible in the multibeam data.

small ripples containing relatively coarse grained material. The ripples themselves also change their size and orientation, clearly in response to local forcing from onshore waves (Fig. 3) and the topographic boundary marking the edge of the ripple scour depression migrates as much as 50 m as fine sand covers the coarse ripple field. Scour marks behind (inshore) of the MCVO node (Fig. 3 -- and other places in the survey area – e.g. as in Fig.2) change orientation in synch with the ripple wave crests indicating that the prevailing transport direction is onshore (in contrast to preconceived view). By April all scours had filled in with fine sand.

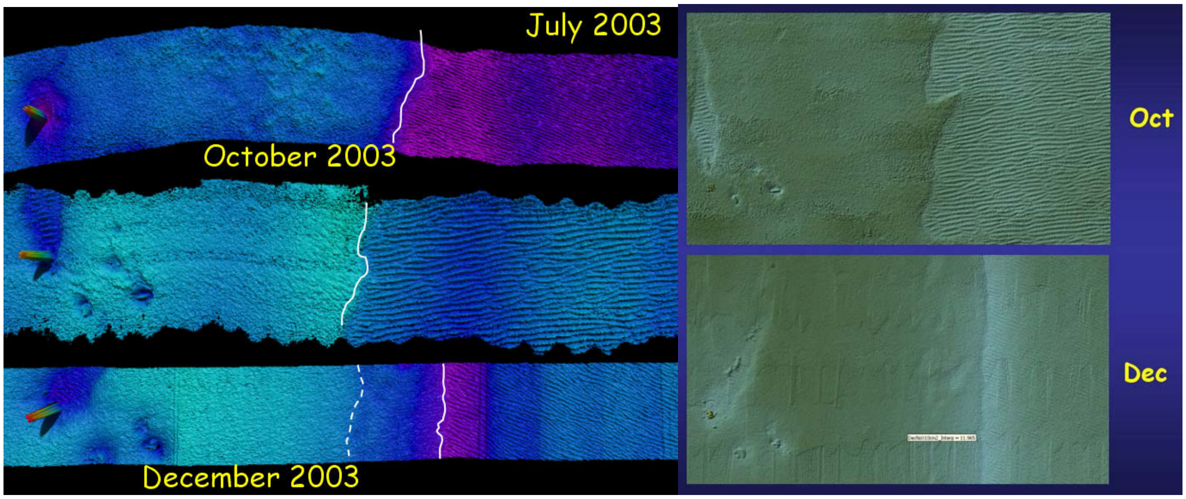

Figure 3. (Left) - Results of three surveys of node area—the MVCO node is seen on the left of each imag, on local topographic high composed of medium to fine sand. On right of each image is local topographic low with ripples developed in coarse sand. A sharp topographic boundary between the fine-med grained high and the coarse grained low is marked in white. July – no mines -- small (2-5 cm) ripples oriented NW-SE. October survey shows mines around node and larger (8-15 cm ripples) oriented E-W. Note scour behind node.

Results from the deployment of the ISSAP were equally successful. During the three-day August cruise, 102 acoustic (sound speed and attenuation) and resistivity (porosity) stations were occupied representing more than 62,000 discrete measurements and more than 30 Gigabytes of data. At nine stations we were able to make measurements at two different frequencies (100 and 65 kHz) and at about half the stations continuous measurements were made as the probes entered the interface. Data quality is very high with measurement accuracy of +/- 0.5 – 1 m/sec for sound speed and +/- 1dB/m for attenuation. Even in this region of relatively limited sediment diversity, the sound varied from 1575 m/sec to 1806 m/sec and attenuation from 6.5 to 59.3 dB/m at 65 kHz. The greatest variation in both sound speed and attenuation appears to be associated with the finer-grained sediments that are less unimodal than the pure coarse-grained sediments consistent with geoacoustic models for both sound speed and attenuation. Dual frequency measurements (at 65 and 100kHz) showed no measurable velocity dispersion. Future work will look at lower frequencies.

Finally the Mine Burial Website is up and available to the community at http://www.mbp.unh.edu. This site contains background information on the program, participant and meeting lists, as well as all data that has been made available to us.

IMPACT/APPLICATIONS

The multibeam surveys have provided the morphological and sedimentological context for all investigators as well as demonstrated the ability to directly detect very small features and identify mine (including their type) on the seafloor. Most importantly, the multibeam data will provide us with an understanding of the distribution of very small-scale bedforms and topography (like the scour-pit) at a scale unobtainable by other means. This, in turn, will hopefully be of tremendous value to the modelers. With ground-truthing studies we hope to gain insight into the mechanisms of sediment transport and the potential for using backscatter to better understand seafloor property changes at the test site. The database will become the central repository for all project related work as well as providing the project team and others the tools necessary for efficient data exploration.

TRANSITIONS

Lessons learned about mine detection with multibeam and sidescan sonar during this work and example data sets from the Martha's Vineyard experiment site have been incorporated into a training course for NAVO and U.S. Navy EOD specialists.

RELATED PROJECTS

GEOCLUTTER, Uncertainty DRI, and RIPPLES DRI.

PUBLICATIONS

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